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Seasonal Movements and Habitat Selection by Woodland Caribou in the Omineca Mountains, North-central British Columbia
Phase 1: The Chase And Wolverine Herds (1991-1994)

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1.0 INTRODUCTION

Conflicts associated with maintaining woodland caribou populations and forest harvesting have focused most habitat use studies on the mountain caribou ecotype residing in southeastern British Columbia (Stevenson and Hatler 1985, Antifeau 1987, Seip 1990, Seip 1992, Terry et al. 1996). Mountain caribou inhabit areas of deep snowpacks in winter, forcing them to forage primarily on arboreal lichens in high elevation forests (Stevenson and Hatler 1985). With increasing demands for forest products and decreasing availability of these resources, the concern has shifted to include woodland caribou populations in the northern part of the province. The northern ecotype resides in areas with low to moderate snowdepths (<1 m), and forages primarily on terrestrial lichens during winter in low elevation commercially valuable forests. To date, only two major studies in the province have focused on northern caribou (Hatler 1986, Cichowski 1989); only the latter study was in relation to forest harvesting concerns.

With the creation of the Williston Reservoir in north-central BC in the late 1960s, an extensive area (1,770 km^2) of wildlife habitat and forest resources was flooded, placing increased pressure for these resources on surrounding lands. Two woodland caribou populations reside west of the reservoir: the Chase and Wolverine Herds (Wood 1996). Both areas are faced with substantial increases in forest harvesting over the next ten to twenty years with resulting increases in road development, loss of mature forests, and potential fragmentation of the landscape.

To address concerns surrounding the protection of woodland caribou and their habitat in the face of imminent harvesting, detailed information on the distribution, habitat use, and movements of caribou in these areas was required. The Omineca Mountains Woodland Caribou Project was initiated in 1991, to be completed in two phases. The objectives of Phase 1 were to determine the seasonal movements, habitat selection patterns, population status, and distribution, of caribou residing west of the Williston Reservoir. These objectives were met by monitoring radio-collared animals from both the Chase and Wolverine Herds on a monthly basis over a three year period (1991-1994), and are the subject of this report. Preliminary data from the first two years of the study is presented in Wood (1996). Phase 2 spanned the subsequent three year period (1994-1997), and focused primarily on the winter and spring use of forested habitats by caribou in the smaller Wolverine Herd (Terry and Wood 1999).

Data gathered on caribou will aid in setting land-use planning priorities, and in developing a caribou/forestry management strategy for the area. This strategy will address the protection of core caribou habitat areas, with specific forest harvesting prescriptions in surrounding areas.

2.0 STUDY AREA

The Omineca Mountains study area encompasses about 21,000 km^2 along the west side of the Williston Reservoir in north-central BC (Figure 1). The study area lies within an area of biogeoclimatic zone transition. Below 1,100 metres, the Sub-Boreal Spruce (SBS) zone in the southern part of the study area gives way to the Boreal White and Black Spruce (BWBS) zone in the north (Meidinger and Pojar 1991). These zones have extensive wildfire histories (Parminter 1984), and forests are dominated by lodgepole pine *(Pinus contorta)* and white spruce *(Picea glauca)*. Variants include the Mossvale moist cool SBSmkl, Williston moist cool SBSmk2, Finlay-Peace wet cool SBSwk2, and the Stikine dry cool BWBSdkl (MacKinnon et al. 1990, DeLong et al. 1993). Between 900 and 1,600 metres, the Engelmann Spruce Subalpine Fir (ESSF) zone in the south is replaced by the Spruce Willow Birch (SWB) zone in the north. Variants include the Omineca moist very cold ESSFmv3, Graham moist very cold ESSFmv4, and the moist cool SWBmk (MacKinnon et al. 1990, DeLong et al. 1994). Climax tree species in the ESSF are the Engelmann spruce *(Picea engelmannii)* and subalpine fir *(Abies lasiocarpd)*. Both white spruce and subalpine fir are found at lower elevations in the SWB, with subalpine fir dominating on higher slopes. Extensive lodgepole pine stands in the ESSF and SWB are uncommon due to infrequent wildfires. Alpine Tundra (ATp) exists at the highest elevations, extending between 1,500 and 2,300 metres. Gentle to moderately sloped windswept terrain is common.

The Chase Caribou Herd inhabits the northern part of the study area (Figure 1). A complex of mountain ranges, which extend westward into broad high elevation scrub/parkland plateaus, characterizes this area. The Butler, Chase and Prospector Ranges in the east are gently sloping rounded ranges with moderate snow accumulations. In contrast, the Osilinka Ranges to the west are steeper and more rugged with high snow accumulations. Extensive forest harvesting has been limited to the lower Mesilinka River valley between the Butler and Prospector Ranges, the lower Osilinka River valley, and the Swanell River and Ravenal Creek drainages.

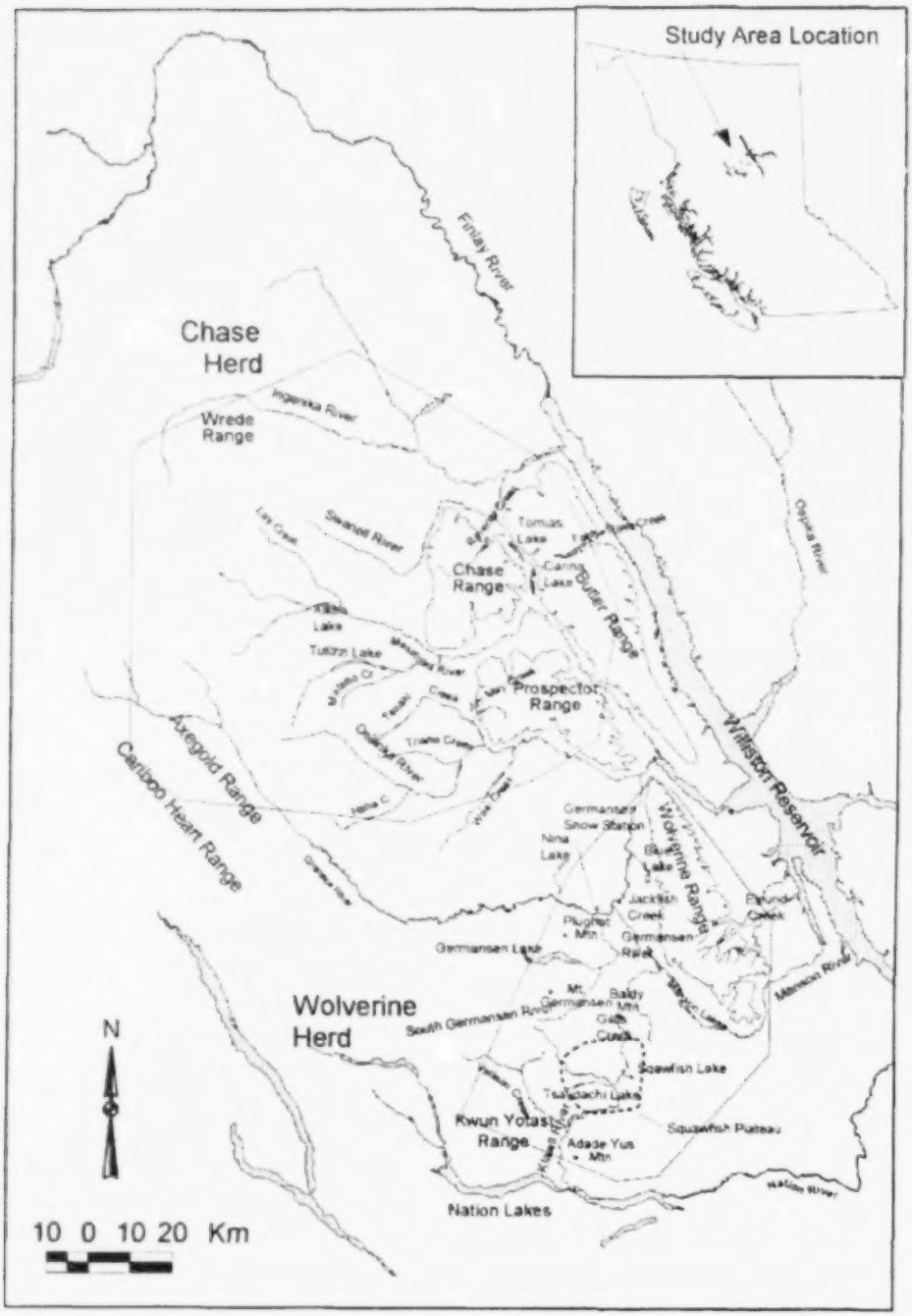

Figure 1. Location of the Chase and Wolverine Caribou Herds in the Omineca Mountains, north-central B.C. Boundaries represent multi-year annual home ranges (1991-94).

The range of the Wolverine Caribou Herd lies in the southern portion of the study area. This area is less mountainous than its northern counterpart, with one primary mountain range in the east (the Wolverine Range) and a few smaller ranges in the west (Figure 1). The herd's range encompasses large portions of the Omineca River and Manson River valleys, and a broad plateau of low elevation (1,000-1,300 m) ESSF in the south. This plateau encompasses the Klawli River, Gillis Creek, Squawfish Lake, and South Germansen River, and is characterized by a large complex of lodgepole pine forests, sedge meadows, wetlands, and small lakes. To date, forest harvesting activities in the range of the Wolverine Caribou Herd have been minimal and are concentrated on the eastern and southern sides of the Wolverine Range.

Moose *(Alces alces)* are common throughout the Omineca Mountains, while mountain goat *(Oreamnos americanus)*, mule deer *(Odocoileus hemionus)*, white-tailed deer *(Odocoileus virginianus)*, Rocky Mountain elk *(Cervus elaphus)*, and Stone's sheep *(Ovis dalli stonei)* are localized and present in smaller numbers. Potential predators of caribou include wolf *(Canis lupus)*, wolverine *(Gulo gulo)*, grizzly bear *(Ursus arctos)*, black bear *(Ursus americana)*, and lynx *(Lynx canadensis)*.

3.0 METHODS

3.1 Capture and Radio-Collaring

Caribou were captured using a handheld net-gun fired from a Bell 206 Jet Ranger helicopter, and fitted with radio-collars equipped with mortality sensors (Model LMRT-4, Lotek Engineering, Newmarket, Ontario). Ten caribou (8F, 2M) were captured and collared from each of the Chase and Wolverine Herds in February 1991. To replace animals that died during the study period and attempt to maintain a sample size of 20 animals, 2 males and 2 females in the Chase Herd were collared in February 1992, and 4 females and 1 male from the Wolverine Herd were collared in March 1992. One additional female was collared in January 1993 in the Wolverine Herd bringing the total number captured during the study period to 30 individuals. Blood samples were taken from females captured in 1991 and 1992 for analysis of serum progesterone levels; values over 2 ng/ml indicated pregnancy (Wood 1996).

3.2 Radio-Telemetry

Thirty-four radio-location flights were conducted from a Cessna 182 fixed-wing aircraft over the three year period: 91/92 (April 1991 - March 1992), 92/93 (April 1992 - March 1993), and 93/94 (April 1993 - March 1994). Monthly flights were attempted, however, poor weather conditions prevented flights in some months (particularly November and December) resulting in small sample sizes. Site characteristics (e.g., tree species, slope, aspect) and group size was recorded for each collared caribou located. Locations were plotted on 1:250,000 topographic maps in the air, then verified immediately after each flight using a combination of 1:50,000 topographic maps, 1:50,000 BCFS forest cover maps, and the site characteristics noted from the air.

3.3 Snow Conditions

Winter snowdepth trends were based on monthly snowdepths measured by BC Environment at the Germansen Snow Station (BC Environment, 1991-1994). The Germansen station is located at 1,500 m on the north side of the Omineca River across from Germansen Landing, in the range of the Wolverine Caribou Herd (Figure 1). This station was selected to best represent the snowdepth trends in the Omineca Mountains study area due to it's central location, and scarcity of other stations throughout the area. Monthly snow depths were graphed and compared between years.

3.4 Seasonal Movements and Ranges

Seasonal movements of collared female caribou were measured as straight-line distances between known seasonal locations. Spring movements were measured between late winter ranges (February or March locations), and late May/early June calving locations. Pre-rut movements were measured between summer ranges (mid-July) and rutting areas (mid-October), while post-rut movements were measured between October rutting locations and late winter ranges (February or March locations). Differences between the mean pre-rut and post-nit distances moved (all years combined) were tested using Student's t-test (StatSoft Inc. 1993).

Individual fidelity to calving and winter ranges was determined for all collared caribou with more than two years consecutive data for each season. Fidelity to a range is defined as an

individual animal returning to a similar geographic location (within a 5 km radius) in consecutive years.

Multi-year home and seasonal ranges were estimated as 100% minimum convex polygons (Mohr 1947) using Ranges V computer program (Kenward and Hodder 1996). Multi-annual home ranges were calculated for each of the Chase and Wolverine Herds using all radio-locations of all collared caribou during the 3 year study period. Multi-year seasonal ranges were also calculated for the two Herds. Four broad seasonal ranges were defined based on caribou movement patterns (i.e., migration, elevational shifts): (i) Spring (1 April - 15 May), (ii) Summer (16 May - 30 Oct), (iii) Early Winter (1 Nov - 30 Dec), and (iv) Late Winter (1 Jan - 31 Mar). Multi-annual home ranges were also calculated for individual caribou with at least 17 radio-locations over the study period.

3.5 Seasonal Habitat Selection

All caribou location co-ordinates were entered into ARC/INFO Geographic Information System, and the forest cover type and biogeoclimatic subzone variant for each location were determined. Slope and aspect were estimated during telemetry flights, while elevation was determined by plotting location coordinates on 1:50,000 topographic maps. Each radio-location was placed into one of five forest cover type categories which were based primarily on leading tree species (Table 1). Five forest cover types were chosen to minimize the probability of TYPE II errors (Alldredge and Ratti 1986).

Radio-locations were also placed into BEC subzone variants, elevation categories (700-1,100 m, 1,101-1,500 m, >1,500 m) (which roughly correspond to broad BEC subzones; BWBS/SBS, ESSF/SWB, AT respectively), aspect categories (cool NW-SE, warm SE-NW), and slope categories (0-15%, 16-30%, >30%). Chi-square analysis (log-likelihood ratio, G-test) was used to test for seasonal differences in use of the BEC variants, elevations, aspects, and slopes. Small sample sizes required pooling of individual locations across years to increase cell frequencies. Availability of the topographic attributes and BEC subzones were not measured, thus analysis was confined to seasonal use comparisons.

Forest cover type availability was determined within each of the Chase and Wolverine Herds' multi-annual and seasonal home ranges (see section 3.4 for descriptions). Each herd's multi-annual home range boundary was used to represent proportions of forest cover types available to that herd over the entire study area. The proportions of each of the five different

Table 1. Description of forest cover types available to woodland caribou in the Chase and Wolverine Herds.

Forest Cover Type	Description
Alpine/subalpine	Non-forested, high elevation alpine tundra and ridge tops, and upper ESSF (> 1,500 m) subalpine dominated by extensive open areas with stunted subalpine fir (i.e., krummholz).
Balsam	Mature forested stands leading in subalpine fir (81+ years), typically mid-elevation (1,100-1,500 m) ESSFmv3 and ESSFmv4.
Spruce	Mature forested stands leading in white and/or Engelmann spruce (81 + years), situated predominately on mid slopes between 1,100-1,500 m (ESSF/SWB), and in valley bottoms at lower elevation (700-1,100 m) within the BWBS/SBS zones.
Pine	Mature forested stands leading in lodgepole pine (61+ years), situated primarily in valley bottoms and lower elevation (700-1,200 m) plateaus within the BWBS/SBS or mid-slope (1,100-1,500 m) stands within the ESSF.
Other	Non-commercial forest types, immature conifer forest, deciduous forest, swamps, lakes, meadows, non-productive brush, burns, clearcuts, and non-forested areas.

forest cover types within each herd's multi-annual and seasonal home ranges were determined using ARC/INFO GIS (Timberline, Vancouver). Appendices 2 and 3 depict the forest cover types available within the multi-annual home ranges of the Chase and Wolverine Herds.

Forest cover selection patterns were analyzed separately for each herd to reflect the different habitat compositions between the two herds ($P < 0.05$) and to meet one of the assumptions of the Chi-square test (i.e., habitat availability is the same for all animals). In general, the Chase Herd had more alpine, and less spruce and pine dominated forests within their annual home range compared to the Wolverine Herd.

Log-likelihood contingency tests of independence (G-test) were used to test for differences in forest cover use among seasons for each caribou herd. To determine second order selection (Johnson 1980), the amount of each forest cover type that occurred in each seasonal home range (100% MCP) was compared to the proportions of forest cover types available in each herds annual home range using the Z statistic (Zar 1987). To determine third-order selection, (i.e., selection of habitats within seasonal home ranges), data were analyzed using Chi-square Goodness-of-fit tests because habitat availability was assumed to be known without error (Thomas and Taylor 1990). If the null hypothesis of random habitat use was rejected, Bonferroni simultaneous confidence intervals were applied to selection ratios to determine which habitats were selected or avoided according to the methods of Manly et al. (1993).

Selection ratios are expressed as:

$$\omega_i = o_i/\pi_i$$

where ω_i is the selection ratio for habitat $_i$, o_i is the proportion of use in habitat $_i$ and π_i is the proportion of habitat i estimated to be available. Approximate simultaneous $100(1-\alpha)\%$ confidence intervals were calculated using the formula:

$$\omega_i \pm z_{\alpha/2I}\, se(\omega_i)$$

where

$$se(\omega_i) = \sqrt{\{(1-\pi_i)/\, u_+ \pi_i\}}$$

I ($Z_{\alpha/2I}$) corresponds to the total number of habitats considered available to the animal and u+ is the total number of use locations. Relative preference and avoidance was inferred if use was significantly greater or less than availability. Selection ratios were ranked from smallest to largest and pairwise comparisons made to determine significant differences between selection ratios (see Manly et al. 1993 pg. 48).

Selection ratios can also be standardized so that they sum to 1 using the formula:

$$B_i = \omega_i/\Sigma\, \omega_i$$

Standardized selection ratios provide a major advantage over traditional chi-square analyses (e.g., Neu et al. 1974) because estimates are not sensitive to the inclusion of large but seldom used habitats. All tests were conducted at the $p = 0.05$ significance level. Although small sample sizes precluded a statistical analysis of inter-annual variation in habitat selection patterns, a descriptive account of habitat use by year is presented.

3.6 Population Characteristics

Collared caribou mortalities were located during radio-telemetry flights with the aid of the motion-sensing mortality collar. Three mortalities were investigated on the ground. Although we were unable to provide precise estimates of annual mortality rates due to small sample sizes, we provide a brief descriptive account of caribou deaths over our study period.

Population densities were calculated for each caribou herd by dividing the estimated caribou population by the average annual home range size of the herd (Bergerud 1992). Winter range densities were also determined by dividing the population size by the average annual winter range size.

4.0 RESULTS

4.1 Radio-Telemetry

Three of the 30 radio-collared caribou were omitted from the database. One male (#342) from the Chase Herd was never located subsequent to its release (possible radio-collar malfunction), and one male (#083) from the Wolverine Herd died shortly after capture (suspected capture myopathy). A second male (#362) from the Wolverine Herd was excluded from the analyses after examination of the data revealed it to exhibit significantly different movement patterns and geographic range use than the other caribou in the herd. For the remaining 27 collared caribou, the mean number of radio-locations per animal over the three year period was 18.2 ± 9.8 SD, with a range of 2 to 32 locations. Seven of the 27 caribou were located less than 10 times throughout the study period: 5 died, 1 could not be located (either it left the study area or its collar malfunctioned), and another that could not be located was located dead approximately one year later.

Radio-telemetry locations of collared caribou in the Chase and Wolverine Herds totaled 210 and 282 locations respectively (Table 2). Half of the locations obtained from each herd were collected during the summer months (mid-May to October); 30% and 35% of these were obtained during the calving period (16 May - 15 June) for the Chase and Wolverine Herds respectively (Table 2).

Table 2. The number of caribou radio-locations obtained by year and season for the Chase and Wolverine Caribou Herds. (1991-1994).

	CHASE HERD				WOLVERINE HERD			
	EW[1]	LW	SP	SU	EW	LW	SP	SU
1991	4	0	15	42	0	0	16	36
1992	6	17	9	34	10	11	16	47
1993	14	23	7	29	30	16	11	54
1994	0	10	n/a[2]	n/a	0	47	n/a	n/a
TOTAL	24	50	31	105	40	62	43	137

[1] EW= Early Winter (Nov 1 - Dec 30); LW= Late Winter (Jan 1 - Mar 31); SP= Spring (April 1 - May 15); SU= Summer (May 16 - Oct 30).

[2] n/a: Beginning of Phase 2 (see Terry and Wood 1999).

4.2 Snow Conditions

Snow conditions differed among the three winters caribou were monitored. Using the 1 March snow depth from the Germansen Snow Station as a benchmark, the 91/92 winter received significantly more snow (36%) than normal and represented a 30 year record high for the Germansen snow station (Figure 2). In contrast, the 92/93 winter was characterized by relatively drier and warmer conditions that resulted in significantly less snow accumulation compared to the previous winter. Snow accumulation during this winter was about 77% of normal. The 93/94 winter was characterized by a slow and below normal accumulation by 1 January but increased to normal levels by February/March. During the winter that the animals were collared (90/91), total snow accumulation was about 27% above normal (Figure 2).

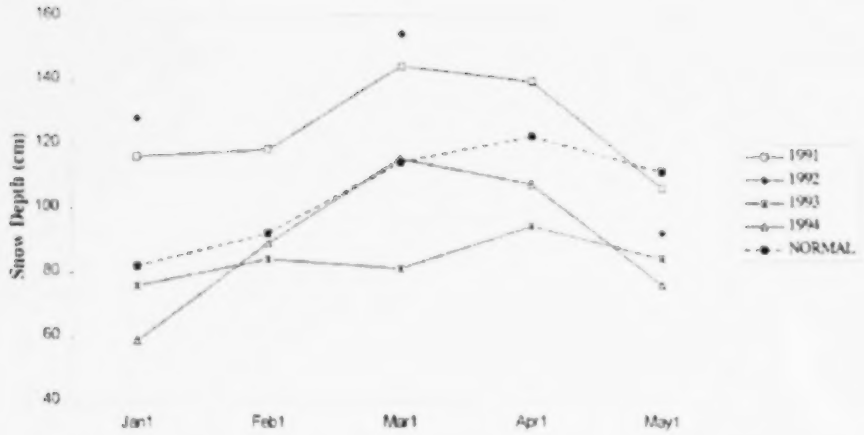

Figure 2. Total monthly snow depths measured at the Germansen Snow Station (1,500m) during the study period (1991-94). Dashed line represents 30 year normal.

4.3 Chase Herd

4.3.1 Seasonal Movements

Most collared females travelled relatively long distances (20+ km) westwards each spring to calving and/or summer ranges, though some remained on winter ranges for the summer (Figure 3). The furthest distance moved by a collared female to a confirmed calving area was 80 km (Mt. Ferguson to Wrede Range); the furthest distance moved to a summer range was 100 km (Mt. Ferguson to Cariboo Heart Range). This latter individual calved near Matetlo Creek 60 km southwest of its winter range, then with its calf, migrated a further 40 km to summer in the Axelgold and Cariboo Heart Ranges. On average, female caribou moved 37.6 ± 24.8 km to calving ranges (all three years combined, n=19).

Five collared females calved in the Osilinka and Tenakihi Ranges, specifically in the mountains around Thane, Matetlo, Haha, Wasi, and Jim May Creeks. Two females calved on Mt. Ferguson and the Chase Range (east of Ravenal Creek) respectively, while a third used both the Wrede and McConnell Ranges in the west. Fidelity to calving ranges was shown by 4 of 5 collared females, though 2 of these returned to their same calving ranges in only 2 of 3 years. These latter individuals produced calves in each of their different calving areas. One individual monitored for only 2 years also produced calves in two different calving areas.

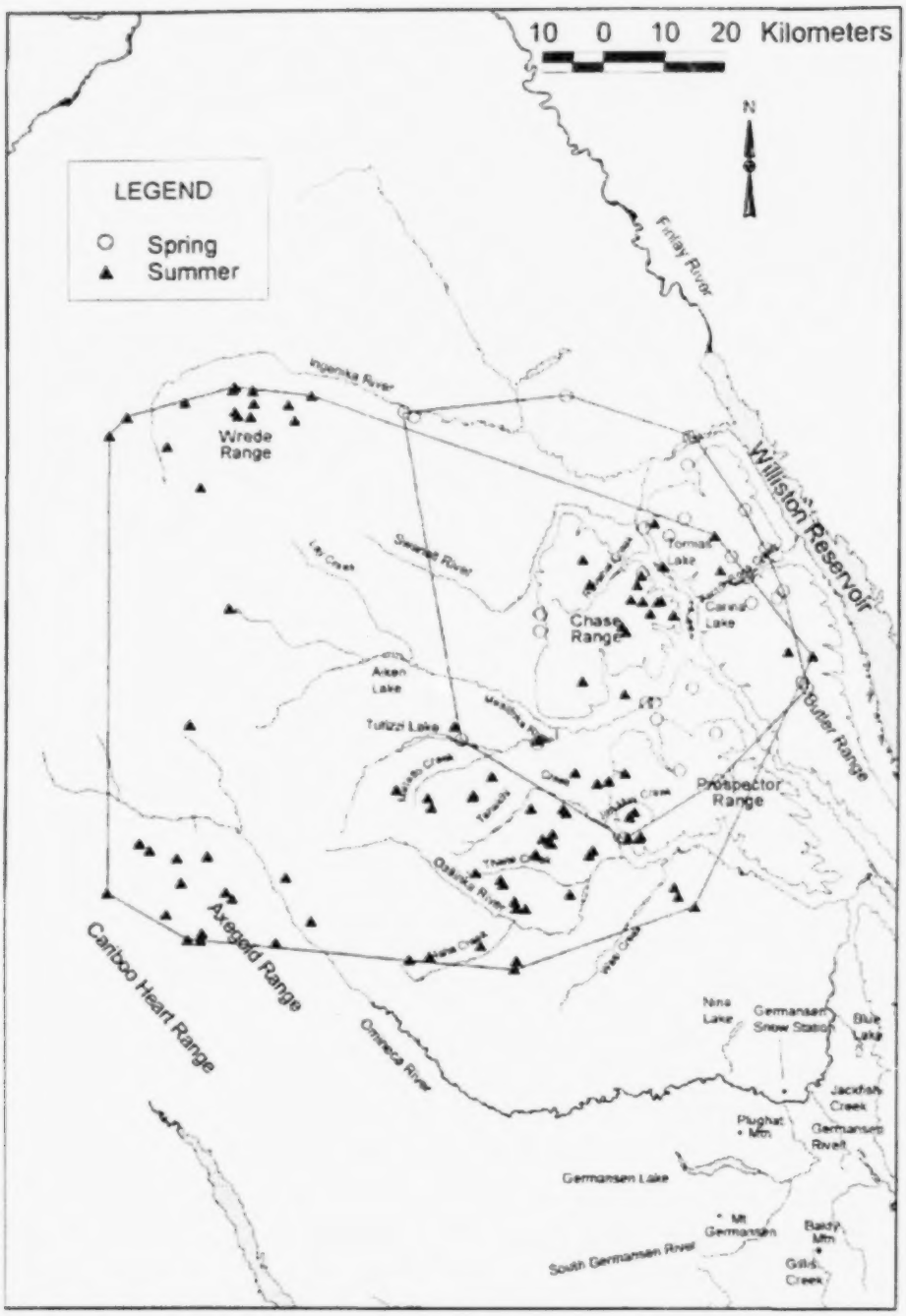

Figure 3. Spring and summer locations of radio-collared caribou in the Chase Herd (1991-94).

Most females that retained calves throughout summer remained on their calving ranges for the summer period (n=5), although some made significant movements (up to 40 km) to summer on different ranges (n=3). Only one female was confirmed to have lost her calf by mid-summer; she moved 27 km from the McConnell to the Wrede Range for summer.

Fall migration to winter ranges occurred primarily after the mid-October mating season suggesting that the rut takes place mainly on summer ranges in the west and southwest part of the study area. Longer movements were made more frequently after the rut (between rut and winter ranges; n=l 1), than before the rut (between summer and rut ranges; n=4), while equal distances were moved before and after the rut only twice (all 3 years combined). However, the mean pre-rut distance moved by caribou (21.6 ± 21.4 km; n=17; range 1-87.5 km) was not significantly different from the mean post-rut distance moved (39.7 ± 32.7 km; n=17; range 2.5 - 110 km) (p=0.064, t= -1.92, df=32). Only one collared female moved a substantial distance on one occasion prior to the rut than after (87.5 vs. 2.5 km).

Primary winter ranges used by collared caribou were in the eastern portions of the study area and included Chase Mtn. (west and east of Ravenal Creek), Butler Range (south of Factor Ross Creek), Prospector Range (north and south of Prospector Creek), and the Mesilinka River near Carina Lake (Figure 4). The Jim May Range and Mt. Ferguson were used to a lesser degree, while only one individual use the Wrede and Espee Ranges. Only 1 of 10 collared caribou appeared to show late winter range fidelity (and only in the latter 2 of 3 years it was monitored). The 9 caribou that did not exhibit fidelity were monitored for 2 (n=3), 3 (n=3) or 4 (n=3) consecutive years (including capture winter).

The mean multi-annual home range size for radio-collared female caribou in the Chase Herd was 1,912 ± 1,335 km^2; *n=l)* (Table 3).

4.3.2 Seasonal Habitat Selection

4.3.2.1 Seasonal Habitat Use

Caribou shifted their use of elevation categories significantly among seasons (G=48.4, 6 df, $P < 0.001$). The majority of caribou locations (>70%) occurred above 1,500 m elevation during both winter and summer (Table 4). In contrast, caribou moved to lower

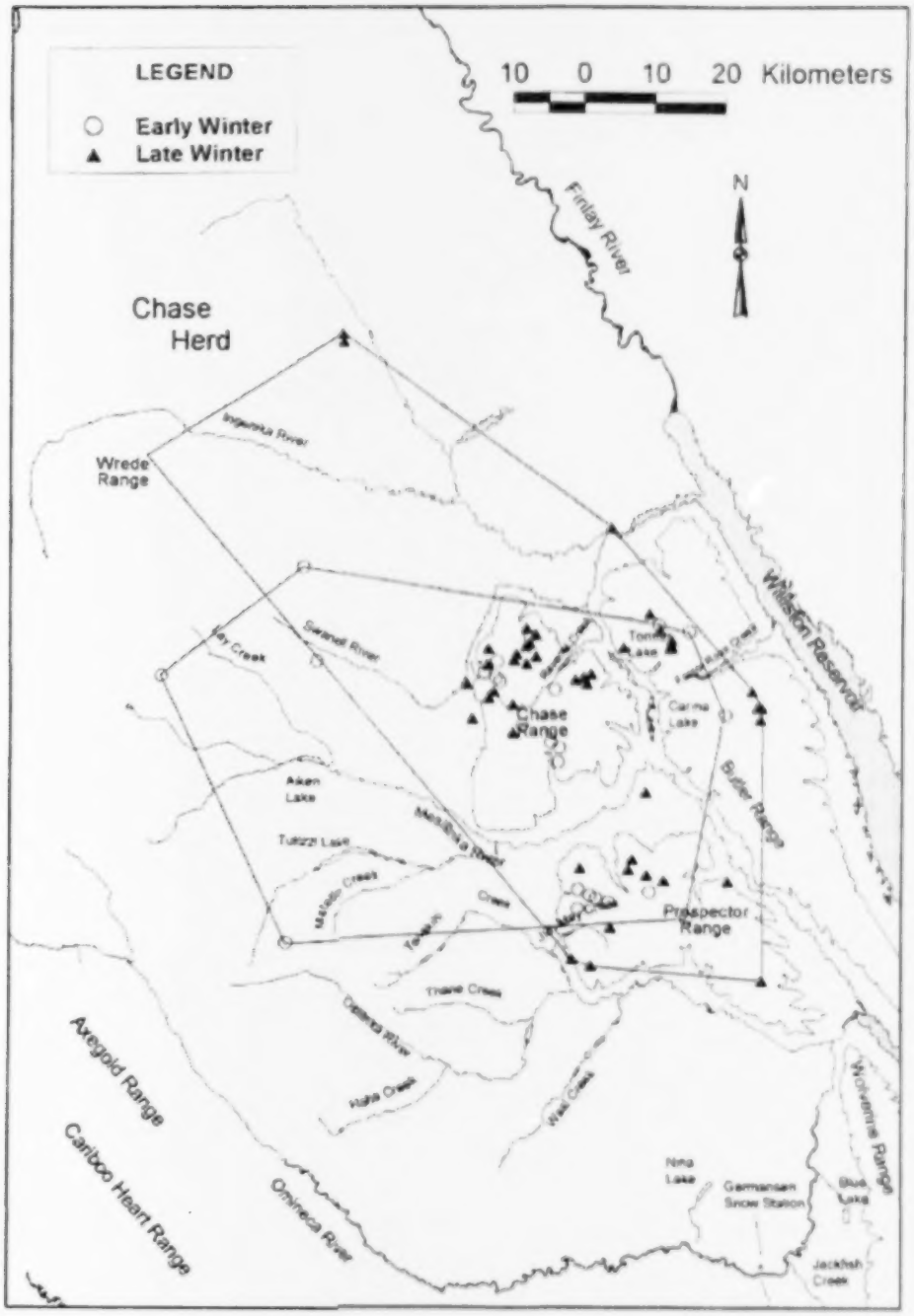

Figure 4. Early and late winter locations of radio-collared caribou in the Chase Herd (1991-94).

Table 3. Multi-annual home range size (100% MCP) of radio-collared caribou in the Chase Herd (1991-94).

Caribou ID#	Sex	# Locations	Home Range Size (km^2)
382	F	26	2,910
402	F	24	3,249
453	F	26	981
474	F	22	3,192
484	F	29	472
504	F	21	670
534	M	17	2,196

elevations (700-1,100 m) during spring. Overall, about 25% of the locations occurred on mid-slopes (1,101-1,500 m) during all seasons. Caribou use of biogeoclimatic subzones corresponded to these elevation shifts. Caribou used the alpine tundra-parkland (ATp) extensively (>65% of locations) during all seasons except spring. During this period, caribou increased their use of lower elevation forests especially those that occur in the BWBSdkl. Caribou used ESSF forests throughout the year, but used ESSFmv4 more frequently during early winter and ESSFmv3 more frequently during summer (Table 4).

Caribou varied their use of forest cover types among seasons (G=29.2, 12 df, P=0.004). Caribou used "other" habitat types (e.g., non-forest types, deciduous forests) significantly more during spring than any other season. In contrast, caribou used these habitat types infrequently during early and late winter. Other significant differences were apparent during summer where low elevation forests dominated by lodgepole pine and Engelmann spruce were used significantly less than other seasons (Table 4).

Although caribou used cool and warm aspects significantly different among seasons (G=11.6, 3 df, *P*=0.009), caribou used all slope categories similarly (P=0.134). Warm aspects received more use during late winter than other seasons, whereas cool aspects were predominately used (70% of locations) during the summer. Overall, the majority of caribou locations (>50%) occurred on flat and relatively gentle slopes (0-15%) during all seasons (Table 4).

Table 4. Seasonal use of biogeoclimatic (BEC) subzones, forest cover types and topographic attributes by radio-collared woodland caribou in the Chase Herd (1991-94). Numbers are % of radio-locations.

Attribute Category	Early Winter (*n* = 24)	Late Winter (*n* =50)	Spring (*n* = 31)	Summer (*n* = 105)
Elevation (m)				
> 1,500	75	70	6	68
1,101-1,500	25	26	26	29
700-1,100		4	48	3
BEC				
ATp	79	68	32	66
ESSFmv4	21	10	16	7
ESSFmv3		14	10	25
SWBmk		4	6	1
BWBSdkl		4	36	2
Forest Cover				
Alpine	63	68	29	68
Balsam	21	10	10	16
Pine	4	8	13	3
Spruce	4	6	6	4
Other	8	8	42	9
Aspect				
Cool	50	42	58	70
Warm	50	58	42	30
Slope (%)				
0-15	58	56	68	55
16-30	34	12	13	20
>30	8	32	19	25

4.3.2.2 Selection of Seasonal Home Ranges

Habitat compositions within early winter, late winter and summer seasonal ranges did not differ ($P > 0.05$) from the estimated study area (annual home range) of the Chase Herd. However, habitat compositions did differ between the spring home range and the annual home range for two habitat types. Spring ranges had significantly less alpine and more pine dominated forests than the Chase study area (Table 5).

4.3.2.3 Selection of Forest Cover Types within Seasonal Home Ranges

Caribou used forest cover types disproportionately ($P<0.05$) in all seasons (Table 6). Habitat selection was most apparent during late winter and summer where caribou selected and "avoided" similar forest cover types. Caribou used alpine/subalpine habitats in proportions greater than their occurrence, and used pine dominated forests significantly less than their availability during these seasons. During early winter, caribou were concentrated in alpine/subalpine habitats and forests dominated by balsam. Together these habitat types accounted for > 80% of the locations. Pine and spruce dominated forests were used less than their occurrence but was not statistically significant due to the small sample size. Caribou used most forest cover types in proportion to their availability during spring, however, "other" (i.e., non-forested areas, lakes) habitats were used extensively and significantly more than their occurrence.

Standardized selection ratios indicated balsam stands were the most likely forest cover type to be selected during the early winter followed by alpine habitats (Table 7). Similarly, alpine and balsam were the two most likely habitats to be selected during late winter and summer. During spring, "other" habitat types were about twice as likely to be selected compared to the next most likely habitat (alpine) and four times more likely compared to the commercial timber types. Pine leading stands were the least likely forest cover type to be selected during all seasons.

Table 5. Comparison of forest cover compositions within the Chase Herd study area (multi-annual herd home range) and seasonal home ranges. Numbers are % of study area and seasonal home ranges (100% MCP).

Forest Cover Type	Study Area	EW[1]	LW	SP	SU
Alpine/Subalpine	46.9	44.9	40.2	*30.8	49.8
Balsam	14.8	10.3	9.6	10.6	16.4
Pine	16.4	23.2	22.0	*25.2	15.1
Spruce	9.1	11.5	9.4	11.8	8.7
Other	12.8	10.2	18.9	21.6	10.0

[1] EW = Early winter; LW = Late winter; SP = Spring; SU = Summer.
* Proportion of seasonal range significantly different from study area proportion; $P < 0.05$ Z-statistic

Table 6. Seasonal availability and use (%) of forest cover types by radio-collared caribou in the Chase Herd, 1991-94.

	Early Winter (*n* = 24)			Late Winter (*n* = 44)			Spring (*n* = 31)			Summer (*n* = 105)		
Habitat	Avail	Use		Avail	Use		Avail	Use		Avail	Use	
Alpine	44.8	62.5	+	40.2	68.0	+	30.8	29.0	+	49.8	66.8	+
Balsam	10.3	20.8		9.6	10.0		10.6	9.7	-	16.4	16.2	
Pine	23.2	4.2		22.0	8.0	-	25.2	12.9		15.1	2.9	-
Spruce	11.5	4.2		9.4	6.0		11.8	6.4		8.7	4.8	
Other	10.3	8.3		18.9	8.0		21.6	41.9	+	10.0	9.5	

plus symbol (+) indicates use is significantly greather than availability ($p<0.05$)
minus symbol (-) indicates use is significantly less than availability ($p<0.05$)
no sign indicates use = availability

Table 7. Seasonal caribou habitat rankings using Standardized Selection Ratios (SSR). Habitats are ranked according to their probability of selection. Chase Herd, 1991-94.

	Early Winter	Late Winter
Habitat	Balsam > Alpine > Other > Spruce > Pine	Alpine > Balsam > Spruce > Other > Pine
SSR[1]	0.424 > 0.292 > 0.171 > 0.076 > 0.038	0.407 > 0.249 > 0.154 > 0.102 > 0.088
	Spring	**Summer**
Habitat	Other > Alpine > Balsam > Spruce > Pine	Alpine > Balsam > Other > Spruce > Pine
SSR	0.401 > 0.194 > 0.187 > 0.112 > 0.105	0.333 > 0.246 > 0.238 > 0.136 > 0.047

[1]Selection ratios of forest cover types connected by horizontal lines are not significantly different from each other ($P > 0.05$).

4.3.2.4 Annual Variation in Habitat Use

Although gaps in the data exist, there was a slight indication that caribou used habitats differently among years. In the winters of 91/92 and 93/94 (with above normal and normal snow accumulations respectively; Figure 2), Chase Herd caribou spent the late winter period on alpine ridges >1,700 m (Figure 5). In contrast, collared caribou remained in mid-elevation (~1,500 m) ESSF habitats during the below normal snow winter of 92/93. Despite the different winter snowpacks that occurred each year (which likely resulted in varying spring conditions i.e., extent of snow-free areas), female caribou in the Chase Herd were found at similar elevations (near tree line) during the calving season each year (Figure 6), before ascending to alpine habitats in June.

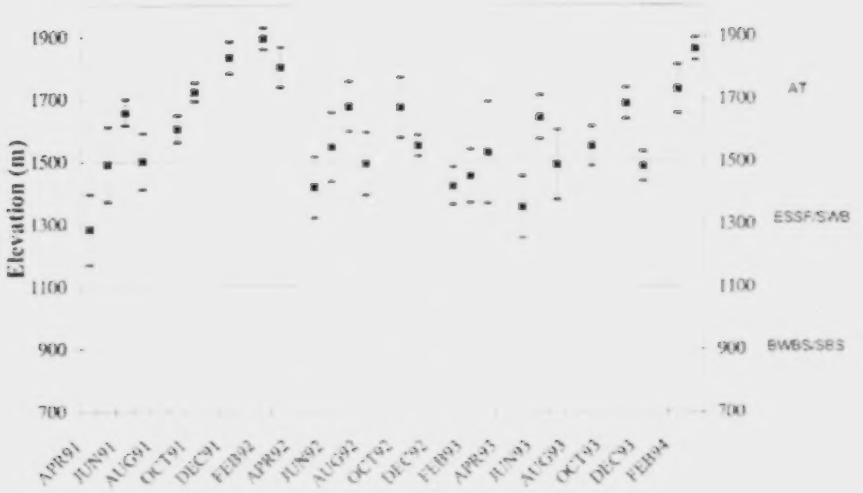

Figure 5. Mean monthly elevations of radio-collared caribou in the Chase Herd over the study period (Apr 91- Mar 94). Error bars are ±1 SE. Solid horizontal lines represent approximate biogeoclimatic zone boundaries.

Figure 6. Mean elevation of female radio-collared caribou in the Chase Herd during calving season (16 May - 15 June) each year, 1991-1993. Vertical bars are ±1 SE.

4.3.3 Population Characteristics

4.3.3.1 Calving

Calving occurred between late May and mid-June, with most calves born in the first week in June. The earliest calf observation date was 27 May (incidental sighting of non-collared female). Calves with collared females were first observed on 5 June (3 of 4 females with calves, 1993); no calves were seen during 26 May flights in 1992 or 1993 (n=4). Serum progesterone levels greater than 2 ng/ml confirmed the parturient status of all females captured in February 1991; 6 of 7 were confirmed with calves on at least one occasion during the year. In 1992, calves were confirmed at some point during the year for 4 of 7 collared females. In 1993, none of the 4 collared females observed in September were with calves, but 3 of 5 collared females had been sighted with calves earlier in the summer.

4.3.3.2 Adult Mortality

Over the 3-year study, 5 female and 2 male radio-collared caribou died (5 captured in 1991, and 2 in 1992; Table 8). Four of the 7 caribou died while in low elevation forested habitats. Mortalities were evenly split between seasons with three in spring/summer, and 3 in early/late winter. A male (#475) that went missing in May 1992, was located dead in September 1993 in the alpine, however, the year and season of death were undetermined. Two mortality sites were investigated; evidence remaining at the sites was scarce but pointed to wolf predation as the primary cause of death. In the Chase Herd, 2 of 8 collared female caribou died in 91/92, 2 of 8 in 92/93, and 1 of 5 in 93/94.

4.3.3.3 Population Density

The maximum area that radio-collared caribou used during the three year study was 10,278 km^2 (multi-annual herd home range). An inventory of two of the Chase Herd's primary alpine winter ranges (Chase Mtn, Butler Ridge) was conducted in February 1993. The mark-resight inventory estimated the herd at 690 ± 202 (SD) caribou; applying the minimum number sighted on the survey, and 95% confidence limits, places the population between 396 and 1085 animals (Wood 1996). Assuming that only caribou that wintered in the census area used the 10,278 km^2 area, the density estimate is 0.067 caribou/km^2 (range between 0.048

Table 8. Radio-collared caribou mortalities in the Chase Herd during the study period (April 1991 - March 1994).

I.D#	Sex	Month/Year	Season	Elevation (m)	Habitat
474	F	May 93	Spring	990	Cutblock
412	F	June 91	Summer	1,700	Alpine
322	F	Jun-Jul 92	Summer	1,250	Pine/Spruce forest
332	M	Oct-Dec 91	Early winter	1,850	Alpine
392	F	Feb-Mar 92	Late winter	1,200	Spruce forest
494	F	Feb-Mar 93	Late winter	1,200	Pine/Spruce forest
475[1]	M	Jun92-Sep93	?	1,770	Alpine

[1]Year and season of death undetermined.

and 0.11 caribou/km^2). The density of caribou using the herds'multi-annual late winter ranges (4,076 km^2) varied between 0.10 and 0.27 caribou/km^2.

4.4 Wolverine Herd

4.4.1 Seasonal Movements

Most radio-collared caribou moved 15-20 km each spring to calving and/or summer ranges. All collared females moved off winter ranges to calve and summer in different areas in 1991 (n=6), while less than half moved to different ranges in 1992 (4 of 9) and 1993 (3 of 10). The furthest distance moved by a collared female between a winter range and confirmed calving area was 35 km (east of Nina Lake to Eklund Creek), while the furthest distance moved to a summer range was 60 km (caribou #524, south end of Wolverine Range to Kwun Yotasi Range) (Figure 7). Female caribou moved an average of 17.2 ± 12.3 km to calving ranges (3 years combined, n=25).

The most important calving areas were the northern and southern ends of the Wolverine Range (particularly Eklund Creek drainage); 9 collared females used these areas for calving (Figure 7). Two females calved in the ranges east of Nina Lake, while 3 females used the Mt. Porter area of the Wolverine Range, Plughat Mtn., and Adade Yus Mtn., respectively. Eight

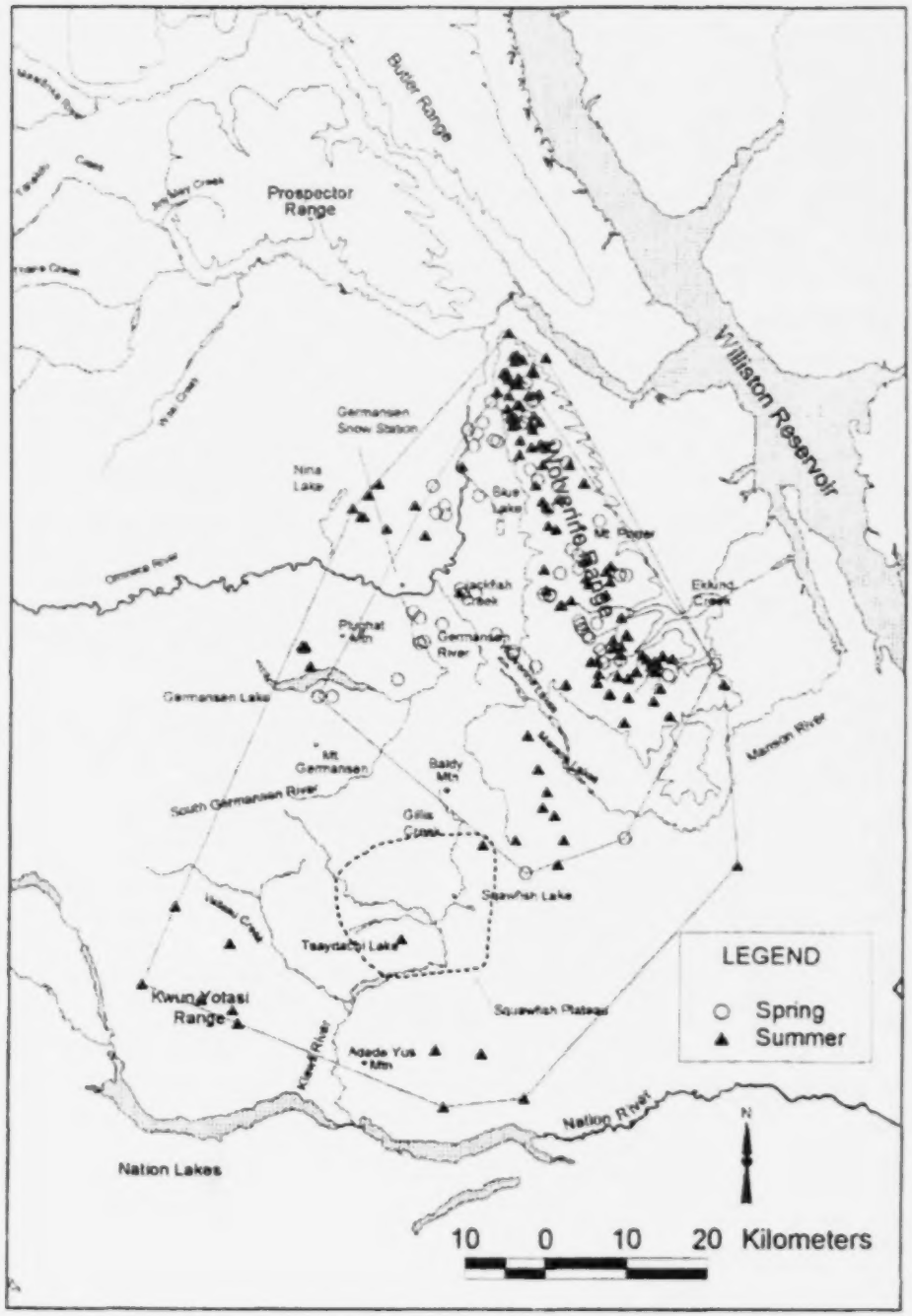

Figure 7. Spring and summer locations of radio-collared caribou in the Wolverine Herd (1991-94).

of 9 collared females showed fidelity to calving ranges, though 3 returned to their same calving ranges in only 2 of 3 years. Calf production in the different areas was unconfirmed for these latter 3 caribou. An individual monitored for only 2 years did bear a calf in each of two different calving areas.

Most collared females remained on calving ranges for the summer period (n=18, all 3 years combined); only 7 movements to other ranges for summer were documented. Data on calf production and survival is insufficient to determine if those animals that lost calves moved to other ranges. The longest distance moved from a confirmed calving area to summer range was 46 km (Plughat Mtn. to Kwun Yotasi Range), and was exhibited in two consecutive years by caribou #524. She was without a calf by late summer in both years.

The majority of rutting activity took place on the Wolverine Range, primarily at the northern and southern ends of the range. Only 1 female annually spent the rut in the Valleau Creek area, before returning to the Mt. Germansen or Wolverine Range for winter. There was no significant difference between the mean pre-rut distance moved by collared caribou (8.6 ± 7.3 km; range 0.5 - 25 km), and the mean post-rut distance moved (12.6 ± 15.2 km; range 2.5 - 66 km) (p=0.28, n=21, all 3 years combined).

Use of early winter ranges varied annually. The Wolverine Range was used by most collared caribou in 92/93 (n=8); while only 2 animals used the Squawfish Plateau (Figure 8). In contrast, 6 of 10 caribou used the Squawfish Plateau during the early winter period of 93/94. Five of these travelled from rutting areas on the south end of the Wolverine Range to the Squawfish area in early November, returning to the Wolverine Range for the late winter period.

The primary late winter range used by collared caribou was the Wolverine Range (all sections of the range were used) (Figure 8). Minor use of the Wolverine Lakes and South Germansen River areas were noted, while 2 individuals used the Germansen Range and Mt. Gillis respectively for one year (Figure 8). Nine of 11 collared animals monitored for more than 2 winter periods (including capture winter) showed some degree of fidelity to their winter ranges, returning to the same ranges for at least two winters. However, fidelity was normally shown in 3 or 4 consecutive years. Fidelity between years was difficult to confirm, since many caribou did not exhibit fidelity within a year. Caribou moved about substantially (>10 km) within the winter of lower snow winter of 92/93.

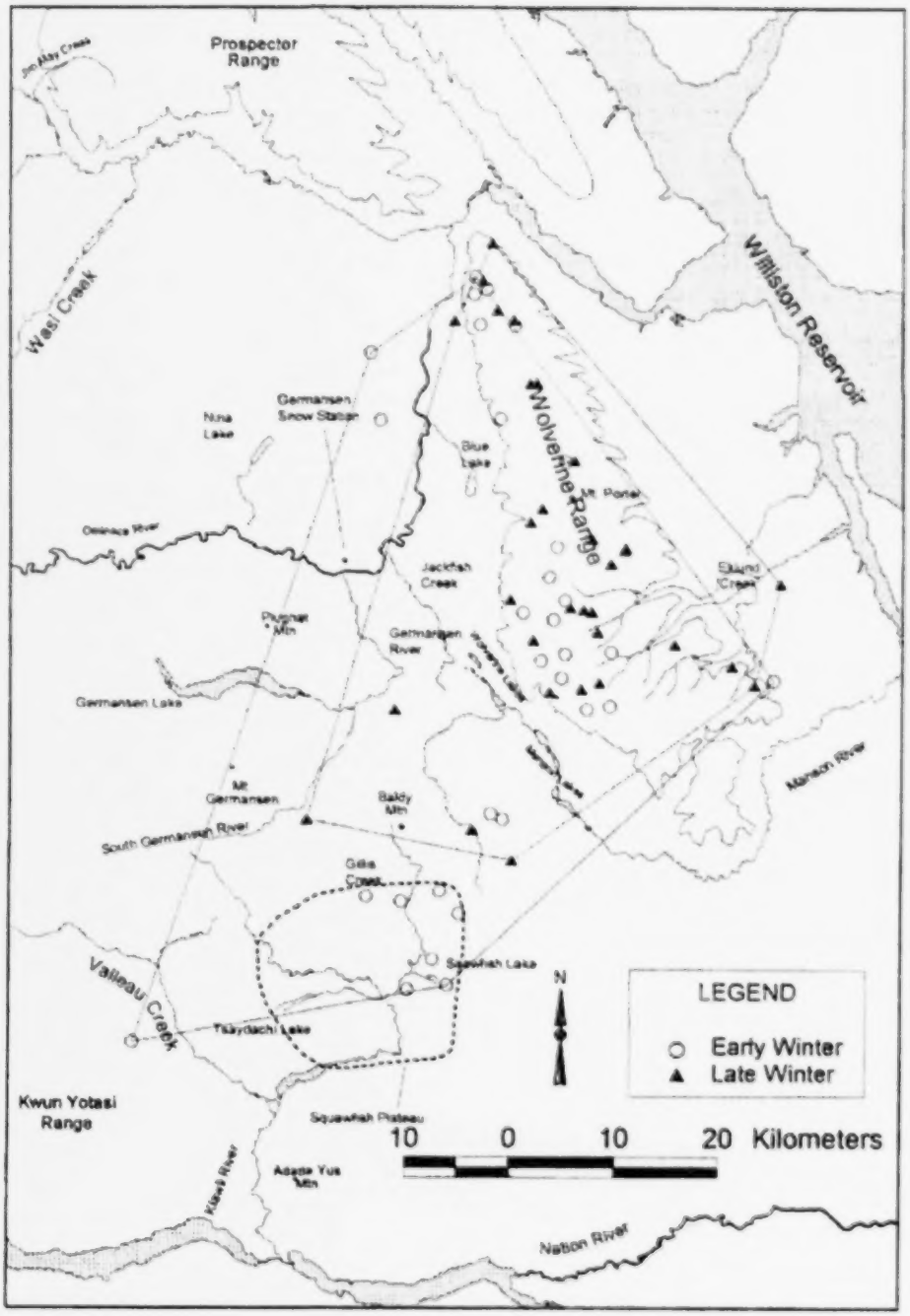

Figure 8. Early and late winter locations of radio-collared caribou in the Wolverine Herd (1991-94).

The mean multi-annual home range for radio-collared female caribou (n=9) in the Wolverine Herd was 731 ± 439 km^2 (range 192 km^2 - 1,521 km^2) (Table 9). Multi-annual home ranges of radio-collared female caribou in the Wolverine Herd were significantly smaller than those in the Chase Herd (t=2.502, df=13, P=0.027). Overall, the maximum area used by radio-collared caribou in the Chase Herd during the 3 year study (10,278 km^2) was over twice that used by the Wolverine Herd (4,396 km^2).

Table 9. Multi-annual home range size of radio-collared caribou in the Wolverine Herd. 100% Minimum Convex Polygon (MCP)

Caribou ID#	Sex	# Locations	Home Range Size (km^2)
312	F	32	942
352	F	25	331
372	F	30	675
433	F	31	514
443	F	29	1,254
464	F	21	421
515	F	22	725
524	F	19	1,521
1893	F	21	192
544	M	27	1,187

4.4.2 Seasonal Habitat Selection

4.4.2.1 Seasonal Habitat Use

Caribou shifted their use of elevation categories significantly among seasons (G=63.5, 6 df, $P < 0.001$). Caribou used mid-elevations (1,101-1,500 m) more frequently during early winter than any other season (Table 10). During late winter, the majority of caribou locations (70%) occurred above 1,500 m. Caribou used all elevations during spring, however, lower elevations (700-1,100 m) received the greatest use (44% of locations) compared to other seasons. By summer, caribou had moved from low elevations back to mid and upper elevations. These elevation differences corresponded with varying seasonal

Table 10. Seasonal use of biogeoclimatic (BEC) subzones, forest cover types and topographic attributes by radio-collared woodland caribou. Wolverine Herd 1991-94. Numbers are % of radio-locations.

Attribute	Early Winter (*n* = 40)	Late Winter (*n* = 62)	Spring (*n* = 43)	Summer (n = 167)
Elevation (m)				
> 1,500	48	73	28	63
1,101-1,500	52	19	28	35
700-1,100		8	44	2
BEC				
ATp	48	73	30	58
ESSFmv3	52	19	19	41
BWBSdkl		6	49	1
SBSmkl/mk2/wk2		2	2	1
Forest Cover				
Alpine/parkland	50	76	28	64
Balsam	8	6	5	20
Pine	12	14	39	4
Spruce	18	2	9	7
Other	12	2	19	5
Aspect				
Cool	58	56	44	56
Warm	42	44	56	44
Slope (%)				
0-15	62	58	53	52
16-30	30	26	21	32
>30	8	16	26	16

uses of biogeoclimatic subzones. Caribou used the ESSFmv3 most frequently during the early winter and summer whereas alpine tundra-parkland (ATp) was used most frequently during late winter. Caribou used the BWBSdkl extensively (49% of locations) only during the spring as they migrated west towards Germansen Landing. In contrast, caribou used low elevation SBS habitats (situated on the east side of the Wolverine Range) infrequently (<3% of locations).

Similar to the Chase Herd, caribou in the Wolverine Herd also varied their use of forest cover types among seasons (G=71.3, 12 df, P= < 0.001). During spring, caribou used mature and old forests leading in lodgepole pine and "other" habitat types significantly more than any other season. Other significant differences were apparent during summer where high elevation forests leading in subalpine fir were used more frequently than other seasons. During early winter, caribou used spruce-dominated forests more often than other seasons (Table 10).

Caribou used both cool and warm aspects equally among all seasons (G=2.2, 3 df, P=0.525). Except for a slight shift to warmer aspects in the spring, about 57% of the locations occurred on cool aspects and the remaining 43% on warm aspects. Caribou also appeared to use slope categories similarly among seasons (P=0.336). Over half (>50%) of the caribou locations occurred on flat and relatively gentle slopes (0-15%) during all seasons, however, caribou increased their use of relatively steep (>30%) slopes during spring (Table 10).

4.4.2.2 Selection of Seasonal Home Range

Habitat compositions within seasonal ranges did not differ (P > 0.05) from the estimated study area (annual home range) of the Wolverine Herd (Table 11).

4.4.2.3 Selection of Forest Cover Types within Seasonal Home Ranges

Caribou used forest cover types in significantly different proportions ($P < 0.05$) than their availability in all seasons except spring ($P = 0.15$; Table 12). During early winter, caribou selected alpine habitats and used forested areas (balsam, pine, spruce) and "other" habitat types in proportion to their availability. Half (50%) of the caribou locations occurred in alpine habitats, 38% were distributed among forested areas (balsam, pine,

Table 11. Comparison of forest cover composition within the Wolverine Herd study area (multi-annual home range) and seasonal home ranges. Numbers are % of study area and seasonal home ranges (100% MCP).

Forest Cover	Study Area	EW[1]	LW	SP	SU
Alpine/Subalpine	14.4	19.2	23.0	22.3	15.0
Balsam	15.0	12.2	13.8	13.1	15.6
Pine	29.7	31.9	27.8	30.0	29.6
Spruce	23.2	21.1	18.1	18.5	23.5
Other	17.6	15.6	17.3	16.1	16.3

[1]EW = Early winter; LW = Late winter; SP = Spring; SU = Summer.

Table 12. Seasonal availability and use of forest cover types by radio-collared caribou in the Wolverine Herd, 1991-94.

	Early Winter (n = 40)			Late Winter (n = 62)			Spring (n = 43)			Summer (n =137)		
Habitat	Avail	Use		Avail	Use		Avail	Use		Avail	Use	
Alpine	19.2	50.0	+	23.0	75.8	+	22.3	27.9		15.0	63.5	+
Balsam	12.2	7.5		13.8	6.4		13.1	4.6		15.6	20.4	
Pine	31.9	12.5		27.8	14.5		30.0	39.5		29.6	4.4	-
Spruce	21.1	17.5		18.1	1.6	-	18.5	9.3		23.5	6.6	-
Other	15.6	12.5		17.3	1.6	-	16.1	18.6		16.3	5.1	-

spruce) and the remaining 12% occurred in "other" habitats types (non-forested areas, swamps, lakes). By late winter, caribou moved out of the forested areas and the "other" habitat type, which resulted in significant 'avoidance' of commercial timber types and non-forested areas including lakes. Caribou returned to these habitat types during spring and used all habitat types in proportion to their occurrence. During summer, caribou selected alpine habitats, but used forested areas and other habitat types significantly less than their availability. Although caribou used balsam stands in proportion to their availability, caribou increased their use of balsam dominated stands (20% of locations) during summer compared to other seasons (Table 12).

Standardized selection ratios indicated alpine/subalpine habitats were at least 3 times more likely to be selected during all seasons except spring where pine leading stands and 'other' habitats were equally likely to be selected as alpine/subalpine habitats. During summer, balsam forest was the next most likely forest cover type selected after alpine (Table 13).

4.4.2.4 Annual Variation in Habitat Use

Although gaps in the monthly data collected exist, there was a slight indication that caribou used habitats differently among years. Caribou spent the late winter period on alpine ridges (>1700 m and > 1,500 m respectively) during the winters with above normal and normal snow packs (91/92 and 93/94; Figure 9). During the below normal snow winter of 92/93, Wolverine Herd caribou appeared to remain at lower elevations in January, but eventually ascended to alpine areas by March (Figure 9).

During calving season, collared females were located mostly in upper ESSF habitats at similar elevations (near tree line) following the above normal snow winters of 90/91 and 91/92, however, following the below normal snow winter of 92/93, caribou appeared to calve at slightly higher elevations (above treeline) (Figure 10).

Table 13. Seasonal caribou habitat rankings using Standardized Selection Ratios (SSR). Habitats are ranked according to their probability of selection. Wolverine Herd, 1991-94.

	Early Winter	Late Winter
Habitat	Alpine > Spruce > Other > Balsam > Pine	Alpine > Pine > Balsam > Other > Spruce
SSR	0.497 > 0.158 > 0.153 > 0.117 > 0.075	0.738 > 0.117 > 0.103 > 0.021 > 0.012
	Spring	**Summer**
Habitat	Pine > Alpine > Other > Spruce > Balsam	Alpine > Balsam > Other > Spruce > Pine
SSR	0.288 > 0.273 > 0.252 > 0.110 > 0.077	0.674 > 0.208 > 0.050 > 0.045 > 0.024

SSR= Standardized selection ratios. Habitats connected by a horizontal line are not significantly different from each other (P > 0.05)

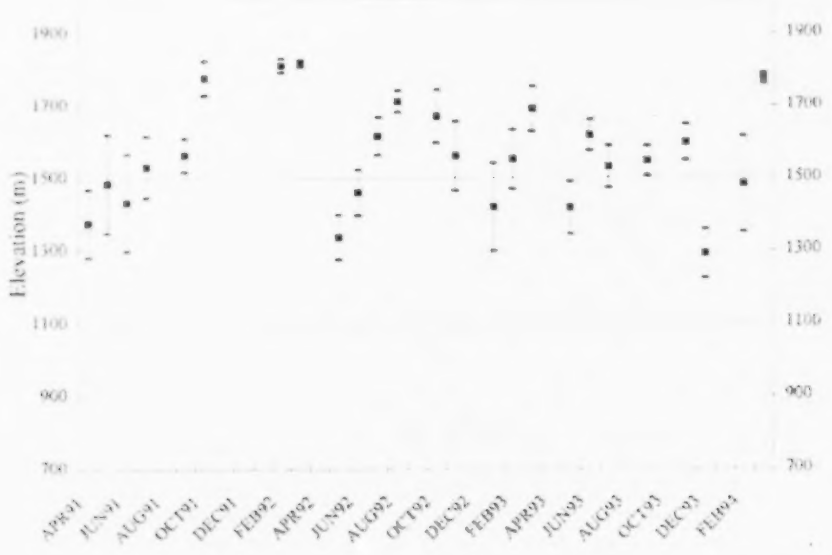

Figure 9. Mean monthly elevations of radio-collared caribou in the Wolverine Herd over the study period (Apr 91- Mar 94). Error bars are ± 1SE. Solid horizontal lines represent approximate biogeoclimatic zone boundaries.

Figure 10. Mean elevation of female radio-collared caribou during calving season (May 16 June 15) each year, 1991-93. Vertical bars are ± 1SE.

4.4.3 Population Characteristics

4.4.3.1 Calving

Calving occurred between late May and mid-June, with most calves born in the first week of June. No collared females in the Wolverine Herd were observed with calves during late May flights in any of the three years (n=10 observations). Calves accompanied 3 of 5 females on 5 June flight in 1993. Serum progesterone levels greater than 2 ng/ml confirmed the parturient status of 4 of 6 females captured in February 1991, although no calves were observed during the year (n=1 to 3 observations/female). At least 3 of the parturient females had lost their calves by September. One of the non-parous females was a yearling; the other's age was unknown. Both females did produce calves in 1992 however. Serum progesterone levels also confirmed the parturient status of all 4 females captured in March 1992. Calves were observed with 3/9 and 6/10 collared females at some point throughout the year in 1992 and 1993 respectively.

In September 1992, 5 of the 9 collared females were without calves, 2 retained calves, and 2 were not observed. By September of 1993, 6 of the 10 females were without calves, 3

retained calves, and 1 was not observed. Assuming all collared females produced calves each year (except the 2 with low serum progesterone levels in 1991), calf survival to 5 months of age (where the collared female was observed) was 0% in 1991 (n=3), 29% in 1992 (n=7), and 33% in 1993 (n=9).

4.4.3.2 Adult Mortality

Over the three year study, three female and one male radio-collared caribou (three captured in 1991, and one in 1992) died (Table 14). The young male captured in March 1992 (#083), died prior to the first telemetry follow-up flight and capture myopathy is suspected. Of the remaining three, all died in spring/summer, and two of the three died while in low elevation forested habitats. One mortality sites was investigated; evidence at the site suggested wolf predation as the primary cause of death. In the Wolverine Herd, 2 of 7 (91/92), O of 9 (92/93), and 1 of 10 (93/94) collared female caribou died.

Table 14. Radio-collared female and male caribou mortalities in the Wolverine Herd during the study period (April 1991 - March 1994).

I.D#	Sex	Month/Year	Season	Elevation (m)	Habitat
493	F	Apr-May 91	Spring	850	Spruce forest
466	F	Apr-Jun 91	Spring	775	Pine/Aspen forest
083[1]	M	Mar-May 92	Spring	1,850	Alpine
352	F	Jul-Aug 93	Summer	1,750	Alpine

[1] Suspected cause of death is capture myopathy

4.4.3.3 Population Density

The maximum area that radio-collared caribou in the Wolverine Herd used during this three year study (Phase 1) was 4,396 km^2 (multi-annual herd home range). The Wolverine Herd was estimated at approx. 200 caribou during a February 1993 mark-resight winter inventory (Wood 1996). The density of caribou in the Wolverine Herd was estimated to be around 0.045 caribou/km^2, assuming that only caribou that wintered in the census area used the 4,396 km^2 area. The density of caribou in the herds'multi-annual late winter range (1,485 km^2) ranges was estimated to be 0.135 caribou/km^2.

5.0 DISCUSSION

The telemetry data presented here suggest both the Chase and Wolverine caribou populations select specific habitat types within their seasonal home ranges. Both herds used alpine habitats (>1,500 m) extensively during all seasons except spring when they increased their use of forested areas. Although the extensive use of alpine habitats during late winter and summer is consistent with other northern caribou habitat studies (Hatler, 1986, Cichowski 1989), the apparent infrequent use of forested habitats, particularly, lodgepole pine forests during the early winter, is not. Other northern woodland caribou populations make extensive use of dry pine-lichen forests during winter where they crater for terrestrial lichens (Edmonds 1988, Cichowski 1989). Despite our results, we believe the apparent avoidance of pine forests is an artifact of the low frequency of flights and the small sample sizes obtained during the early winter periods. In fact, subsequent monitoring of the Chase Herd has indicated caribou make greater use of valley bottom pine forests during winter (MELP 1998, Skeena Region, unpublished data). In addition, more intensive monitoring of the Wolverine Herd (see Phase 2) indicated caribou select lodgepole pine forests as well as fen/wetland habitats during early winter (Terry and Wood 1999).

Both herds made extensive use of alpine habitats during winter, however, the Chase Herd also appeared to use upper elevation subalpine-fir forests to a greater extent than the Wolverine Herd, despite similar availability of this forest cover type within their seasonal home ranges. In addition to the forage available on windswept alpine ridges (i.e., sedges, grasses, terrestrial lichens), greater use of subalpine-fir forests suggests caribou in the Chase Herd may feed on arboreal lichens to a greater extent than caribou in the Wolverine Herd.

Although sample sizes were small, there was an indication that annual snow conditions influenced habitat selection patterns during winter. Instead of ascending to alpine ridges which occurred in both the above normal and normal snow years (91/92 and 93/94 respectively), caribou appeared to remain in mid elevation ESSF habitats during the low snow winter (92/93). Although lower snow accumulation may have enabled caribou to remain in lodgepole pine forests to crater for terrestrial lichens, it is not clear from these data how lower snow accumulation would benefit caribou foraging in mid to high elevation spruce-fir forests where presumably only arboreal lichens would be available. Deep snow depths are known to impede caribou movement and reduce terrestrial forage availability which increases energy expenditures required to obtain forage (Fancy and White 1985, Thing 1977), and may partly explain why caribou ascend to windswept ridge tops during above

average snow years. Although snow depths are likely reduced on alpine ridges as well during low snow years, caribou are likely choosing forested habitats that provide relatively more terrestrial or arboreal lichens than alpine areas. During years of either normal or above average snowfall, deep snows apparently force caribou onto windswept ridges to forage on exposed terrestrial lichens, sedges and grasses.

The Chase Herd appeared to make bi-annual movements between their calving and summer areas located in the Osilinka and Wrede Ranges, and their winter ranges located primarily to the east in the Prospector, Butler and Chase Ranges. Caribou in the Chase Herd also appeared to use similar areas during both early and late winter. In contrast, some caribou in the Wolverine Herd appeared to have more distinct early and late wintering areas (i.e., less overlap).

During summer caribou in both herds used alpine and subalpine areas extensively (>80% of locations). The mean elevation of caribou locations (1,500-1,600 m) during the calving season suggests female caribou calve near treeline. This study, and others in northern B.C. have also documented use of calving areas near treeline and rocky outcrops (Bergerud et al. 1984, Hatler 1986, Cichowski 1989, Wood 1996). Female caribou may be calving at higher elevations to avoid predation by wolves in valley bottom habitats. Dispersion in mountains has been proposed as an anti-predator strategy to reduce the risk of predation (Bergerud and Page 1987, Seip 1992). Indeed, the majority of female caribou mortalities recorded in this study were in low elevation (<1,200 m) forests. Caribou in the Chase Herd appeared to calve and spend the summer in more rugged terrain compared to caribou in the Wolverine Herd. Although dispersion into rugged terrain should have resulted in less mortality due to predation in the Chase Herd, mortality rates were actually slightly higher in the Chase Herd. Although reasons for increased mortality rates remain speculative, more extensive forest harvesting within the range of the Chase Herd may have resulted in an increase in moose populations and wolves rendering the anti-predator strategy of spatial segregation less effective.

Caribou appear to show strong fidelity to calving areas in both the Chase and Wolverine Herds. Caribou in the Chase Herd calved primarily in the Osilinka and Tenakihi Ranges, however, the Wrede, Mt. Ferguson, and Chase Ranges were also used by some caribou. In the Wolverine Herd, caribou showed strong fidelity primarily to the southeastern (near Eklund Creek) and northern sections of the Wolverine Range. Fidelity to calving sites has

also been reported in other woodland caribou studies in British Columbia (Cichowski 1989, Hatler 1986), Alberta (Edmonds 1988), and Manitoba (Shoesmith and Story 1977).

Caribou were present at densities of 0.067 caribou/km^2 in the Chase Herd and 0.045 in the Wolverine Herd. These density estimates are consistent with other densities reported for caribou populations that space out in alpine areas during summer and where wolves are not exploited (Bergerud 1992, Seip and Cichowski 1996).

6.0 MANAGEMENT RECOMMENDATIONS

6.1 Chase Herd

Except during spring, the Chase Herd used alpine and upper elevation ESSF forests almost exclusively. Although this appears to suggest very little direct conflict between forestry and caribou, subsequent caribou monitoring (MELP, Skeena Region, unpublished data; PWFWCP, unpublished data) has indicated greater use of low elevation lodgepole pine forests during winter, particularly along the Swanell and upper Mesilinka River valleys. Thus, continued monitoring in this area appears warranted to identify and confirm which habitat types are being used as winter foraging areas as well as main travel corridors. The telemetry data from this study, however, suggests caribou likely cross the Swanell and upper Mesilinka River valleys as they move back and forth between the Osilinka Ranges and Chase Mountain. In addition, caribou that winter on the Prospector Ranges including the ridge near Jack May Creek likely travel along the Osilinka River and Tenakihi Creek as they migrate to their calving and summer range in the Osilinka Ranges. Therefore, until further data becomes available, these areas should be managed as movement corridors.

Ranges used annually for calving include the Osilinka Ranges (particularly between Tutizzi and Wasi Lakes), Tenakihi Ranges (around Jim May Creek), Mt. Ferguson, Chase Range (east of Ravenal Creek), Wrede Range, and McConnell Range. Forest harvesting in and around calving areas can negatively affect caribou by altering seral stage distributions, which may lead to increased predation (Seip 1992,1998). In addition, resource development activities increase road access and human disturbance, which can result in habitat displacement (Dau and Cameron 1986). Therefore, calving areas should be considered as

high priority management areas where resource development activities are either prohibited or minimized.

6.2 Wolverine Herd

For a complete description of management recommendations relating to the Wolverine Herd, the reader is referred to Phase 2 (Terry and Wood 1999).

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APPENDIX 1.0

Capture and radio-location dates for radio-collared caribou:

Chase and Wolverine Herds (1991-94).

Capture Dates: Feb 6/7/8, 1991 Feb 20, 1992 Mar 19, 1992 Jan 12, 1993												CHASE HERD																							
Capture Date			Mar-92	Jan-93	Feb-98	Feb-91	Feb-91	Feb-91	Feb-91	Feb-91	Feb-91	Feb-91	Feb-91	Feb-91	Feb-91	Feb-91	Feb-91	Feb-91	Feb-9	Mar-92	Feb-91	Feb-91	Feb-92	Feb-93	Feb-91	Feb-92	Feb-92	Mar-92	Mar-92	Feb-92	Feb-91	Mar-92		
Herd			W	W	W	W	W	C	C	C	W	W	C	C	C	C	W	W	C	W	W	C	C	C	W	C	C	W	W	C	W	W		
Capture Locn			wolvn	gen	wolv	wolv lk	wolv s	meadn	meadn	meadn	wolv s	man lk	ferguson	meadn	meadn	ferguson	wolv s	man lk	henri	wolv n	wolv n	ferguson	pross s	henri	wk s	butt m	pross s	wolv s	wolv s	butt m	wolv lk	wolv m		
Sex			M	F	F	F	F	F	M	M							F	F	F	F	F	F	M	F						M	M	F		
Age			1-2	2-3	adult		small	large	large	small		2-3						1-2		2-3	wlcalf	older	2-3		large	4-5	2-3	2-3	4+	2-3		3*		
Caribou ID #			83	110	121	302	312	322	332	342	352	372	382	392	402	412	433	443	453	464	466	474	475	484	493	494	504	515	524	534	544	1893		
91/92	8-Apr					X	X	gen	X	-	X	X	X	gen	X	X	X	X	X		-	X		-	-						X			
	18-Apr					X	X	g	X	-	X	X	X	X	X	X	X	X	X		X	X		X	X						X			
	27-May					X	X	X	X	-	X	X	X	X	-	X	X	X	X		-	X		X	dead						X			
	20-Jun					X	X	X	-	-	gen	X	X	X	-	dead	X	X	X		dead	X		X							X			
	23-Jul					X	X	X	-	-	X	X		X	X		X	-	X			X		X							gen			
	6-Sep					X	X	X	X	-	X	X	X	X	X		X	X	X			X		X							-			
	25-Sep					X	X	X	X	-	X	X	X	X	-		X	X	X			X		gen							-			
	25-Oct					-	X	X	-	-	X	X	X	X	X		X	gen	X			X		X							-			
	19-Dec					-	gen	X	dead	-	gen	gen	-	-	x		gen	gen	-			-		X							-			
	5-Feb					-	X	X		-	X	X	X	gen	X		X	X	X			X		X							-			
	17-Mar					-	X	X		-	X	X	X	dead	X		X	X	X			X	X	X		X	X			X	X			
92/93	6-May		dead			-	X	X			X	X	X		X		X	X	X	X		X	X	X		X	gen	X	gen	X	X	X		
	13-May					-	X				X	X					-	-										X			X	X		
	26-May					-	X	X			X	X			gen		X	X	X	X		X	X	X		X	X	X	X	-	X	X		
	12-Jun					-	X	-			X	-	X		X		X	X	X	X		X	-	X		gen	X	X	X	gen	X	gen		
	15-Jul						X	dead			X	X	X		-		X	X	X	X		X	-	X		X	X	X	X	gen	X	X		
	31-Aug					-	X				X	gen	X		X		X	X	X	X		X	-	gen		X	X	X	X	X	X	X		
	6-Oct					-	X				X	X	X		X		X	X	X	X		X	-	X		X	X	X	X	-	X	X		
	23-Nov					-	X				X	X			X		X	X	X	X		X	-	X		X	X	X	X	gen	X	X		
	6-Jan						X				X	X			X		X	X	X	X		X	-	X		X	X	X	gen	X	X	X		
	11-Feb			X			X				X	X	X		X		X	X	X	X		X	-	X		X	X	X	X	X	X	X		
	12-Mar			X			X				X	X	X		X		X	X	X	X		X	-	X		dead	X	X	X	X	X	X		
93/94	4-May			X			X				X	X	X		X		X	X	X	X		X	-	X			X	X	X	X	X	X		
	26-May			X			X				X	X	X		-		X	X	X	X		dead	-	X			X	X	X	X	X	X		
	5-Jun			X			X				X	X	X		-		X	X	X	X			-	X			X	X	X	X	X	X		
	14-Jul			X			gen											X													X			
	19-Jul						X				X	X	X		X		X		X	X				X			X	X	X	X		X		
	2-Sep			X			X				dead	X	X		X		X	X	X	X				X			X	X	X	X	X	X		
	28-Sep			X			X					X	X		-		X	X	X	X			dead	X			X	X	X	X	X	X		
	4-Nov			X			X					X	X		X		X	X	-	X				X			X	X	X	X	X	X		
	23-Nov			X			X					X	X		X		X	X	-	X				X			X	X	X	X	X	X		
	20-Dec			X			X					X			X		X	X	-	X				X			X	X	X	X	X	X		
	8-Feb			X			X					X	X		X		X	X	-	X				X			X	X	X	X	X	X		
	28-Mar			X			X					X	X		X		X	X	-	X				X			X	X	X	X	X	X		

LEGEND:

x = animal located during tracking flight

"-" = animal not located during tracking flight

dead = collar emitting mortality signal

gen = general location obtained, no precise coordinates

empty cell = animal not tracked, dead, or not yet collared

HERD: W=Wolverine, C=Chase

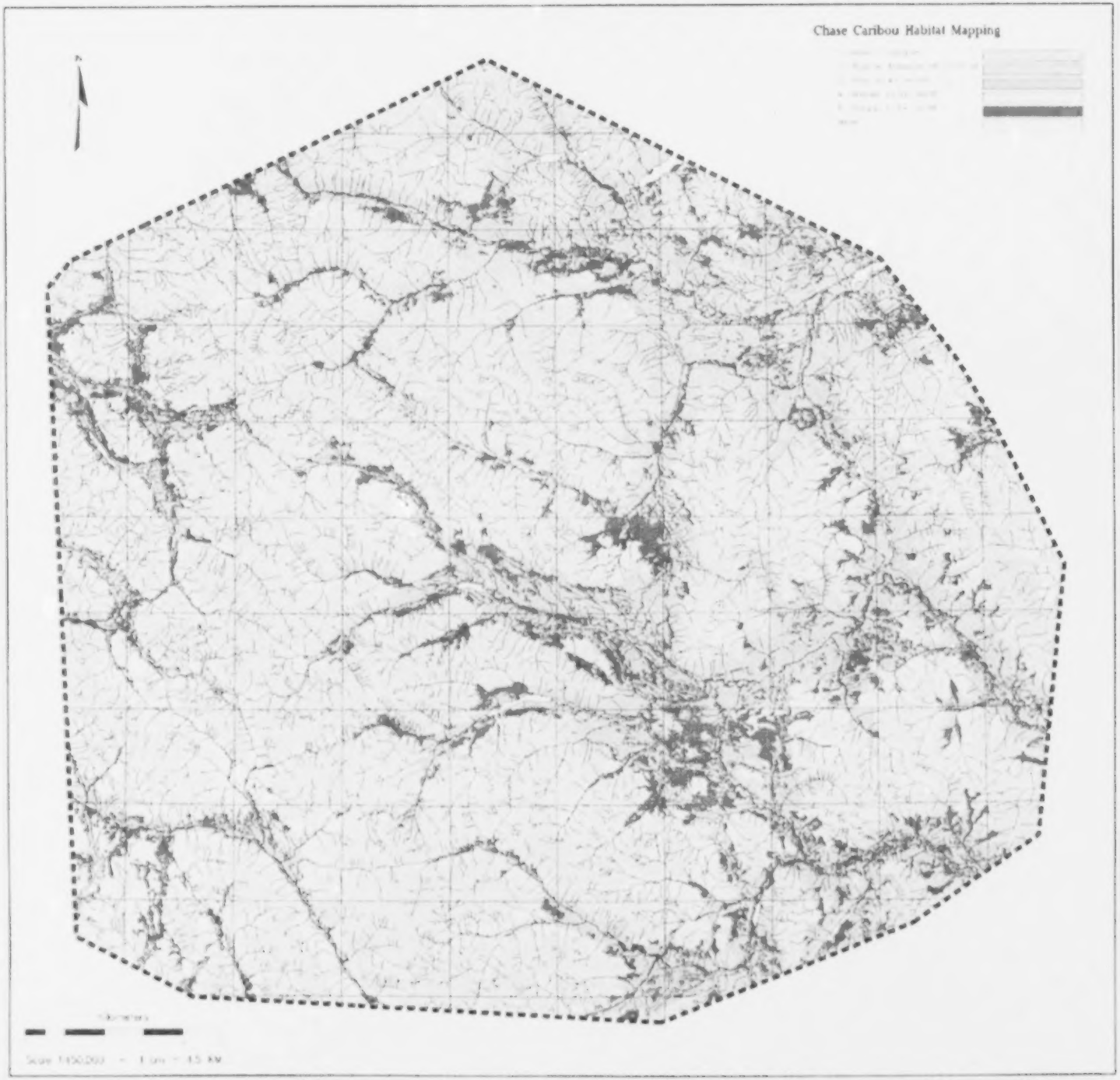
Capture Dates:	Feb 6/7/8, 1991	Mar 19, 1992	Jan 12, 1993	March 29, 1994	November 2, 1995	February 29, 1996	March 1,1996		WOLVERINE HERD						
Capture Date	Jan-93	Feb-96	Mar-96	Mar-96	Mar-96	Feb-91	Feb-91	Feb-91	Feb-91	Mar-92	Mar-92	Mar-92	Feb-91	Mar-94	Mar-94	Mar-94	Mar-94	Mar-94	Nov-95	Feb-96	Nov-95	Nov-95	Nov-95	Nov-95	Nov-95	Feb-96	Mar-92
Capture Locn	gilla	wolv r	wolv N	germ r	wolv r	wolv s	man lk	wolv s	man lk	wolv n	wolv s	wolv s	wolv lk	wolv s	wolv s	wolv s	wolv n	wolv s	klawli	wolv r	klawli	klawli	gilla Cr.	gilla Cr.	gilla Cr.	wolv r	wolv m
Sex	?	F	F	F	M	F							M	M	M	M	M	M	F	F	M	F	F	M	F	M	F
Age	2-3	adult	2	adult	adult	small	2-3		1-2	2-3	2-3	4+		2-3	2	5-6	2-3	4	2-3	adult	8+	yrlg	2-3	4-5	2	adult	3+
Caribou ID #	110	121	131	151	180	312	372	433	443	464	515	524	544	610	620	630	642	650	753	761	772	781	792	901	912	921	1893
94/95 9-Apr	x					x	x	x	x	x	x	x	x	x	x	x	x	x									x
18-Apr	x					x	x	x	x	x	x	x	x	x	x	x	x	x									x
28-Apr	x					x	x	x	x	x	x	x	x	x	x	x	x	x									x
8-May	x					x	x	x	x	x	x	x	x	x	x	x	x	x									x
19-May	x					x	x	x	x	x	x	x	x	x	-	x	x	x									x
2-Jun	x					x	x	x	x	x	x	x	gen	x		x	x	x									x
10-Jun	x					x	x	x	x	x	x	x	x	x	-	x	x	x									x
12-Nov	-					gen	x	dead	x	gen	x	x	x	x	-	gen	gen	x									x
20-Nov	x					x	x		x	gen	x	x	x	x	-	gen	gen	x									x
28-Nov	x					x	x		x		x	x	x	x	-			x									
3-Dec	x						x		x	x	x	x	x	x	-	x	x	x									x
9-Dec	gen					x	x		gen	gen	x	x	gen	x	-	dead	x	x									x
13-Dec	x					gen	-		x		x	x	x	x	-			x									
20-Dec	x					gen	x		x	gen	x	x	x	x			gen	x									
31-Dec	x					x	-		x	x	x	x	x	x	-		x	x									x
19-Jan	x					x	-		x	x	x	x	x	x			x	x									x
26-Jan	x					x	-		x	x	x	x	x	x			x	x									x
2-Feb	x					x	-		x	x	x	x	x	x			x	x									x
27-Feb	x					x	-		x	x	x	x	x	x			x	x									x
12-Mar	x					x	-		x	x	x	x	x	x			x	x									x
25-Mar	x					x	-		x	x	x	x	x	x			x	x									x
95/96 10-Apr	x					x	-		x	x	x	x	x	x			x	x									x
17-Apr	x					x			x	x	x	x	x	x			x	x									x
26-Apr	x					x			x	x	x	x	x	x			x	x									x
9-May	-					x			x	x	x	x	x	x			x	x									x
18-May	x					x			x	x	x	x	x	x			x	gen									x
25-May	x					x			x	x	x	x	x	x			x										x
31-May	x					x			x	x	x	x	x	x			x	x									x
7-Jun	x					x			x	x	x	x	x	x			x	x									x
14-Jul	x					x			x	x	x	x	x	x			x	x									x
8-Oct	x					gen			-	x	x	gen	x	x			x	gen									dead
1-Nov	x					x			-	x	x	x	x	x			x	x									
10-Nov	x					x				x	x	x	x	x			x	x	x		x	x	x	x	x		
29-Nov	x					x			-	x	x	x	x	x			x	x	x		x	x	x	-	-		
9-Dec	x					dead				x	x	x	x	x			x	x	x		x	x	x	x	x		
22-Dec	x									x	x	x	x	x			x	x	x		x	x	x		x		
30-Dec	x									x	x	x	x	x			x	x	x		x	x	x		x		
5-Jan	x									x	x	x	x	x			x	x	x		dead	x	x		x		
17-Jan	x									x	x	x	x	x			x	x	x			x	x		x		
2-Feb											x	x	x	x			x	x	x				x		x		
20-Feb	x									x	x	x	x	-			x	x	x			x	x		x		
7-Mar				x								x					x					x	x				
17-Mar	x		x		x					x	x		x	x				x	x	x					x	x	

| Capture Dates: | Feb 6/7/8, 1991 | Mar 19, 1992 | Jan 12, 1993 | March 29, 1994 | November 2, 1995 | February 29, 1996 | March 1, 1996 | | WOLVERINE HERD | | |

APPENDIX 2.0

Forest cover types within the multi-annual home range of the

Chase Caribou Herd (1991-94)


Chase Caribou Habitat Mapping

APPENDIX 3.0

Forest cover types within the multi-annual home range of the Wolverine Caribou Herd (1991-94).

Wolverine Caribou Habitat Mapping